CLAIMS:

1   1. A method of diagnosing pathologic heart conditions comprising:

2   parsing a time series of heart sounds into a sequence of individual heart cycles;

3   determining the systolic interval of the heart cycles;

4   identifying a subinterval for each systolic interval of the heart cycles;

5   filtering the time series of heart sounds using a time-frequency transformation;

6   identifying anomalously high wavelet coefficients using a constant false alarm rate

7   (CFAR) detector;

8   assembling the series of anomalously high detections into a matrix;

9   convolving the matrix with an averaging vector, said vector's length derived from the

10   expected time spread of a click occurrence, the convolution yielding detection statistics

11   across heart cycles and time intervals consistent with an observed spread of click occurrence

12   times;

13   calculating a click score as the maximum element of a vector formed by the median

14   wavelet coefficient amplitude across heart cycles squared at each time sample multiplied

15   element-wise by a vector formed by the sum across heart cycles of the number of detections

16   at each time sample; and

17   comparing the click score to a threshold level in order to distinguish between a normal

18   heart and a pathologic heart.

1   2. The method of claim 1 further comprising ranking the click score relative to other click

2   scores in a database to establish its standing amongst a population of other click scores of

3   known pathologic and non-pathologic hearts.

1   3. The method of claim 1 wherein parsing the time series of heart sounds into a sequence of

2   individual heart cycles uses electro-cardiogram (ECG) data to transform a time series of

3   heart sounds into a sequence of individual heart cycles.

4. The method of claim 1 wherein parsing the time series of heart sounds into a sequence of individual heart cycles uses acoustic heart sounds obtained directly from a patient to transform a time series of heart sounds into a sequence of individual heart cycles.

5. The method of claim 1 wherein determining the systolic interval of the heart cycles is achieved by identifying pulses on an electro-cardiogram (ECG).

6. The method of claim 1 wherein determining the systolic interval of the heart cycles is achieved by acoustically locating a first and a second heart sound using a bandpass filter, said bandpass filter applied to the time series of heart sounds.

7. The method of claim 1 wherein the systolic sub-interval is centered in the systolic interval.

8. The method of claim 1 wherein the systolic sub-interval is centered in systole and spans half of the systolic interval.

9. The method of claim 1 wherein filtering the time series of heart sounds using a time-frequency transformation is implemented by a second order coiflet continuous wavelet transform (CWT).

10. The method of claim 1 wherein filtering the time series of heart sounds using a time-frequency transformation is implemented by a Fourier transform.

11. A system for diagnosing pathologic heart conditions comprising:
    means for parsing a time series of heart sounds into a sequence of individual heart cycles;
    means for determining the systolic interval of the heart cycles;
    means for identifying a subinterval for each systolic interval of the heart cycles;
    means for filtering the time series of heart sounds using a time-frequency transformation;
    means for identifying anomalously high wavelet coefficients using a constant false alarm rate (CFAR) detector;

1   means for assembling the series of anomalously high detections into a matrix;

2   means for convolving the matrix with an averaging vector, said vector's length derived

3 from the expected time spread of a click occurrence, the convolution yielding detection

4 statistics across heart cycles and time intervals consistent with an observed spread of click

5 occurrence times;

6   means for calculating a click score as the maximum element of a vector formed by the

7 median wavelet coefficient amplitude across heart cycles squared at each time sample

8 multiplied element-wise by a vector formed by the sum across heart cycles of the number of

9 detections at each time sample;

10   means for comparing the click score to a threshold level in order to distinguish between a

11 normal heart and a pathologic heart; and

12   means for ranking the click score relative to others in a database to establish its standing

13 amongst a population of other scores of known pathologic and non-pathologic cases.

1   12. The system of claim 11 further comprising means for ranking the click score relative to

2   other click scores in a database to establish its standing amongst a population of other

3   click scores of known pathologic and non-pathologic hearts.

1   13. The system of claim 11 wherein the means for parsing the time series of heart sounds into

2   a sequence of individual heart cycles uses electro-cardiogram (ECG) data to transform a

3   time series of heart sounds into a sequence of individual heart cycles.

1   14. The system of claim 11 wherein the means for parsing the time series of heart sounds into

2   a sequence of individual heart cycles uses acoustic heart sounds obtained directly from a

3   patient to transform a time series of heart sounds into a sequence of individual heart

4   cycles.

1   15. The system of claim 11 wherein the means for determining the systolic interval of the

2   heart cycles is achieved by identifying pulses on an electro-cardiogram (ECG).

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16. The system of claim 11 wherein the means for determining the systolic interval of the heart cycles is achieved by acoustically locating a first and a second heart sound using a bandpass filter, said bandpass filter applied to the time series of heart sounds.

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17. The system of claim 11 wherein the systolic sub-interval is centered in the systolic interval.

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18. The system of claim 11 wherein the systolic sub-interval is centered in systole and spans half of the systolic interval.

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19. The system of claim 11 wherein the means for filtering the time series of heart sounds using a time-frequency transformation is implemented by a second order coiflet continuous wavelet transform (CWT).

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20. The system of claim 11 wherein the means for filtering the time series of heart sounds using a time-frequency transformation is implemented by a Fourier transform.

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21. A computer program product for diagnosing pathologic heart conditions, the computer program product comprising:

computer program code for parsing a time series of heart sounds into a sequence of individual heart cycles;

computer program code for determining the systolic interval of the heart cycles;

computer program code for identifying a subinterval for each systolic interval of the heart cycles;

computer program code for filtering the time series of heart sounds using a time-frequency transformation;

computer program code for identifying anomalously high wavelet coefficients using a constant false alarm rate (CFAR) detector;

computer program code for assembling the series of anomalously high detections into a matrix;

1   computer program code for convolving the matrix with an averaging vector, said vector's

2   length derived from the expected time spread of a click occurrence, the convolution yielding

3   detection statistics across heart cycles and time intervals consistent with an observed spread

4   of click occurrence times;

5   computer program code for calculating a click score as the maximum element of a vector

6   formed by the median wavelet coefficient amplitude across heart cycles squared at each time

7   sample multiplied element-wise by a vector formed by the sum across heart cycles of the

8   number of detections at each time sample;

9   computer program code for comparing the click score to a threshold level in order to

10   distinguish between a normal heart and a pathologic heart; and

11   computer program code for ranking the click score relative to others in a database to

12   establish its standing amongst a population of other scores of known pathologic and non-

13   pathologic cases.

1   22. The computer program product of claim 21 further comprising computer program code

2   for ranking the click score relative to other click scores in a database to establish its

3   standing amongst a population of other click scores of known pathologic and non-

4   pathologic hearts.

1   23. The computer program product of claim 21 wherein the computer program code for

2   parsing the time series of heart sounds into a sequence of individual heart cycles uses

3   electro-cardiogram (ECG) data to transform a time series of heart sounds into a sequence

4   of individual heart cycles.

1   24. The computer program product of claim 21 wherein the computer program code for

2   parsing the time series of heart sounds into a sequence of individual heart cycles uses

3   acoustic heart sounds obtained directly from a patient to transform a time series of heart

4   sounds into a sequence of individual heart cycles.

1   25. The computer program product of claim 21 wherein the computer program code for
2   determining the systolic interval of the heart cycles is achieved by identifying pulses on
3   an electro-cardiogram (ECG).

1   26. The computer program product of claim 21 wherein the computer program code for
2   determining the systolic interval of the heart cycles is achieved by acoustically locating a
3   first and a second heart sound using a bandpass filter, said bandpass filter applied to the
4   time series of heart sounds.

1   27. The computer program product of claim 21 wherein the systolic sub-interval is centered
2   in the systolic interval.

1   28. The computer program product of claim 21 wherein the systolic sub-interval is centered
2   in systole and spans half of the systolic interval.

1   29. The computer program product of claim 21 wherein the computer program code for
2   filtering the time series of heart sounds using a time-frequency transformation is
3   implemented by a second order coiflet continuous wavelet transform (CWT).

1   30. The computer program product of claim 21 wherein the computer program code for
2   filtering the time series of heart sounds using a time-frequency transformation is
3   implemented by a Fourier transform.